Previous sections have outlined the trend shown in root causes of noncompliance, from (1) lack of management structure and oversight, and lack of operating procedures prior to EMS implementation to (2) human error and failure to follow established procedures after EMS implementation. The results of this study indicate that the implementation of EMSs and its associated structure and procedures may offer the advantage of helping a facility to focus on environmental compliance issues. This statement is based on a combination of the analysis of the root and contributing causes of noncompliance as well as improved compliance rates at participating UTC facilities, including both (1) fewer total instances of noncompliance at each facility, and (2) fewer facilities with individual instances of noncompliance. In addition, noncompliance that was identified during the 1998 audits typically was much less severe than that identified during the 1990 inspections. For example, the 1990 inspections found widespread noncompliance resulting in a consent decree and a multi-million dollar penalty. By contrast, a number of the instances of noncompliance identified during the 1998 audit were deemed sufficiently minor that no penalty was associated with them in the Report of Violations.

7.0 POLLUTION PREVENTION PRACTICES AT UTC FACILITIES

This section describes the elements of a P2 program that were present at UTC facilities in 1990 and in 1998, as expressed by personnel of UTC facilities in response to the pre- and post-EMS surveys. In general, the use of the surveys was not effective in eliciting specific details about P2 projects implemented at participating UTC facilities. The elements of a P2 program agreed upon for this project are listed in Section 5 of the pre-EMS survey and Section 4 of the post-EMS survey (see Appendix B).

7.1 Limitations and Qualifications

The responses presented in this section may be limited in their accuracy by the fact that the personnel completing the pre-EMS survey may not have had access to personnel who have first-hand knowledge of P2 practices in place at a facility in 1990. In addition, as discussed in greater

detail below, the responses are limited by the way in which UTC records and tracks P2 information.

7.2 Elements of a P2 Program in 1990

Six of the eight facilities that responded to the survey indicated that they had been engaged in P2 activities in 1990. All eight of the responding facilities indicated that, in 1990, they had not been required to have in place a formal P2 plan, and each reported that it did not have such a plan. The P2 activities at UTC facilities implemented in 1990 typically consisted of spill prevention and other "housekeeping" measures. In conversations between UTC personnel and Tetra Tech personnel, the P2 efforts in place in 1990 were characterized as "informal." However, beginning in 1988, all participating UTC facilities had measurement and reporting mechanisms in place for hazardous waste and toxic air emissions to meet the requirements of EPA. These mechanisms provided a baseline for setting P2 goals and promoting future P2 efforts.

7.3 Progress in Pollution Prevention During Implementation of an EMS

In the period from 1990 to 1998, various P2 initiatives related to an EMS were implemented at the corporate level at UTC to promote P2 activity at the divisions and at individual facilities. Specifically, senior management of UTC began setting P2 goals during that time period. In UTC's first EH&S annual report, prepared in 1992, progress in the reduction of hazardous waste and toxic air emissions is reported against a 1988 baseline. A goal of 50 percent reduction by 1995 was established. After 1995, UTC established reduction goals for the year 2000 of 80 percent for hazardous waste and 95 percent for toxic air emissions (compared with the 1988 baseline).

Since 1992, UTC has prepared a public report on its progress against P2 goals. In addition,

> Increased emphasis on reporting and management review has contributed to the significant focus on accountability and innovation for P2.

progress has been tracked continuously at all levels of management, from factory operations to the board of directors.

7.4 Elements of a Pollution Prevention Program in 1998

Information in the post-EMS surveys indicates that the P2 activities reported generally were more sophisticated than activities reported in the pre-EMS surveys. For example, the post-EMS surveys cited specific examples of material substitution and source reduction that had been implemented between 1990 and 1998. As the information presented in Appendix B shows, the surveys were designed to provide very specific information about P2 practices; however, specific information about P2 practices before 1990 generally was not available. Subsequent to the surveys being completed, business unit-level examples of P2 practices were provided by UTC to EPA from available P2 reports. In the post-EMS surveys, all the facilities reported that they maintained a formal P2 plan. Notably, only three of those eight facilities stated that they were required under state law to have P2 plans.

7.5 Comparison of Pollution Prevention Elements in 1990 and 1998

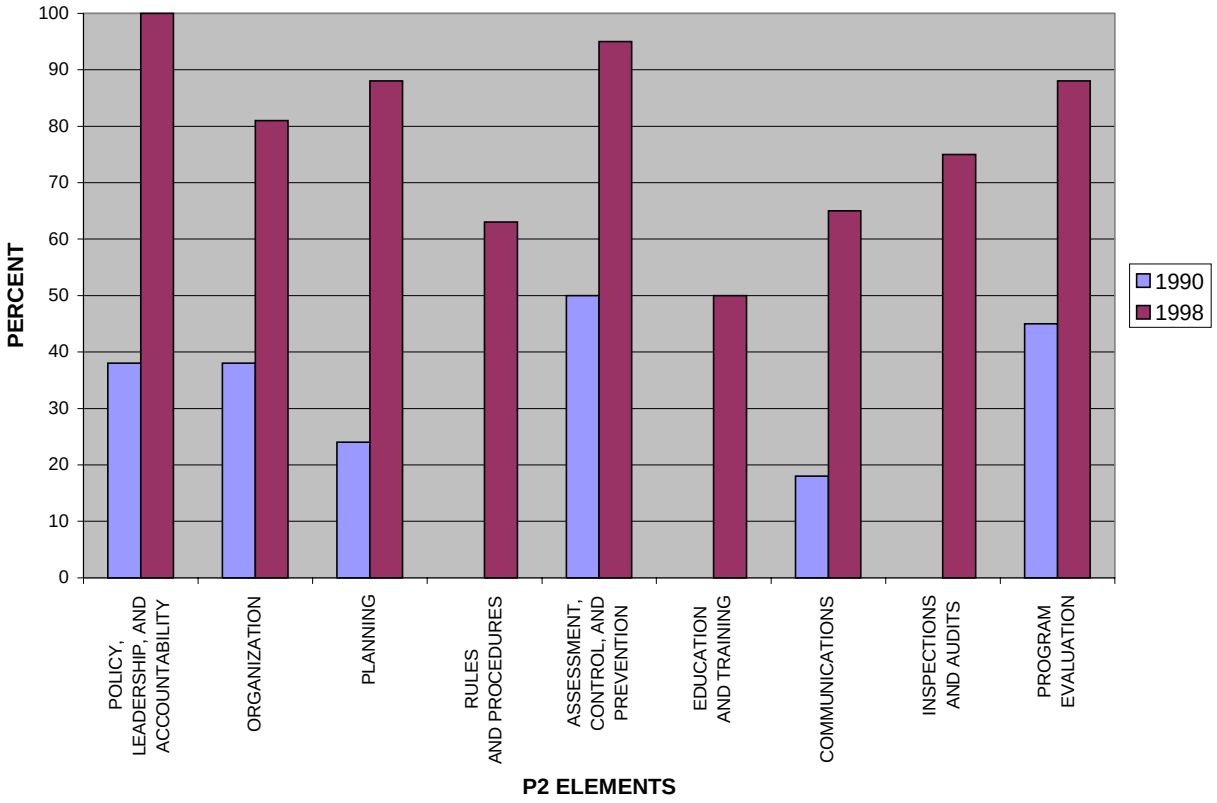
Table 5 shows the elements of a P2 program that were present in 1990 and 1998, as indicated by UTC's responses to the pre- and post-EMS surveys. The table shows the total number of specific elements of a P2 program at each facility, before and after implementation of an EMS. The numbers of specific P2 elements under each general element are shown in parentheses in the first column of the table. The table also shows the number of specific P2 elements for each facility reported in the pre-EMS survey (represented by the first of two numbers presented in an X/X format) and in the post-EMS surveys (reported by the second of two numbers).

Table 5
COMPARISON OF P2 ELEMENTS AT PARTICIPATING UTC FACILITIES: 1990 vs. 1998

General Element of a P2 Program	Hamilton Sundstrand	P&W Colt Street	P&W East Hartford	P&W Middletown	P&W North Haven	Rocky Hill	Sikorsky Stratford	UTRC
Policy, Leadership, and Accountability (2)	1/2	1/2	1/2	0/2	2/2	0/2	0/2	1/2
Organization (4)	2/4	2/3	2/3	1/4	3/2	1/4	0/3	1/3
Planning (18)	5/16	6/15	6/15	2/18	6/16	1/18	0/14	9/15
Rules and Procedures (3)	0/2	0/2	0/2	0/1	0/3	0/2	0/1	0/2
Assessment, Control, and Prevention (7)	4/7	4/7	3/7	3/6	3/6	3/7	3/7	5/7
Education and Training (2)	0/1	0/1	0/1	0/0	0/1	0/2	0/2	0/0
Communications (5)	5/5	0/3	0/3	1/0	0/5	1/5	0/2	0/3
Inspections and Audits (1)	0/1	0/1	0/1	0/0	0/1	0/1	0/0	0/1
Program Evaluation and Results (5)	3/5	3/5	3/5	1/0	0/5	1/5	5/5	3/5

In general, the responses to the pre- and post-EMS surveys indicate that many more elements of a P2 program were in place in 1998 than were in place in 1990. Figure 14 shows the average number of P2 elements as a percentage present at the participating UTC facilities in 1990 and in 1998.

Figure 14. Percent of P2 Elements Present



Information about P2 efforts received by EPA from UTC included:

- Several issues of *Waste Lessons*, a quarterly publication that highlights waste minimization and P2 activities throughout UTC
- Various examples of P2 activities implemented at the eight participating UTC facilities

Specifically, examples of P2 activities implemented at the eight participating UTC facilities between 1990 and 1998 include:

- UTC has reduced toxic air emissions by 92 percent corporate wide by eliminating ozone-depleting substances formerly used in vapor degreasers. Specifically, Sikorsky replaced numerous vapor degreasers with mechanical washers and immersion tanks, thereby reducing the use of perchloroethylene by 200,000 pounds annually.

- Hamilton Sundstrand reduced volatile organic compound (VOC) emissions and saved $1 million in capital and operating costs by inventing its own water-based coolant to replace a more toxic solvent-based coolant.

- In 1992, Sikorsky began to use a central filtration system to recover and reuse machine coolant. The new process reduced the volume of hazardous waste that was produced by 13,000 gallons per year.

- By applying a flocculation process and a closed-loop recycling system to wastewater from its vibratory bowls, P&W North Haven reduced metal hydroxide sludge generated by 60 percent and water use by more than 50 percent.

- In 1996, P&W North Haven began to use a vacuum distillation unit for nitric acid that has eliminated the use of nitric acid and will save the company more than $700,000 over five years.

- In 1998, Sikorsky introduced the use of plastic media blasting (PMB) to reduce the amount of waste generated by traditional paint-stripping operations. Use of the process has eliminated the average annual generation of 350,000 pounds of wastewater previously managed as hazardous waste, as well as reduced the amount of solid waste by 200 pounds per aircraft.

- Compared with the 1988 baseline, the amount of hazardous waste generated has been reduced 83 percent.

A review of the information provided by UTC indicates that more elements of a P2 program were in place in 1998 than in 1990, as reported in the pre- and post-EMS surveys. It also is apparent that more P2 activities were being documented (or documented more thoroughly) in 1998 than in 1990. However, a definitive statement about the effect of the implementation of an EMS on P2 efforts at individual facilities is difficult because:

- Much of the information compiled by UTC (for example, hazardous waste generation rates and use of toxic chemicals as identified under EPCRA) does not appear to be maintained permanently by UTC at the facility level, making comparisons of circumstances at individual facilities difficult.

- Information about individual production rates is not available for many of the participating facilities, so it was not possible to normalize P2 results for production. UTC uses sales as the basis on which to normalize P2 activities.

- It appears that many early (that is, pre-1992) P2 efforts were not recorded formally. Therefore, establishment of a "baseline" description of P2 efforts is extremely difficult.

8.0 UTC's RECOMMENDATIONS FOR COMPLIANCE ASSISTANCE

The corporate EMS survey solicited recommendations from UTC about possible approaches to compliance assistance. Those recommendations are set forth below.

- UTC suggested that EPA and the states replace their current (administrative) systems with performance-based systems.
- UTC indicated a desire for more consistency on the part of EPA and the states in interpreting environmental regulations.
- UTC indicated that priorities should be established for the use of federal and state government and industry resources related to compliance, according to the risk that particular operations pose to human health and the environment.
- UTC suggested that more detail accompany notices of violation (NOV) to aid a facility in taking corrective actions; UTC stated that recommendations from the regulatory agencies (that is, examples of compliant approaches at other facilities) would be helpful.
- UTC encouraged more familiarity among EPA and state regulators with facility operations and more communication between facilities and EPA and state regulators.

9.0 COMPARISONS TO THE RCA PROJECT

This section provides a comparison of the findings of this project with the EPA/CMA Root Cause Analysis Pilot Project (RCA project). As was previously noted, this project used a methodology very similar to that developed for the RCA Project. Particularly as this is the first effort to build on the work of that study, it is useful to evaluate how the findings of this effort compare with those of the RCA project. The subsections below include (1) a comparison of the RCA Project noncompliance and root cause categories with the UTC 1998 survey results and (2)